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LINKING OF THE "BENSON" GRAPH-PLOTTER WITH THE "ELEKTRONIKA-100I"
COMPUTER

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16. Abstract Described herein is a device, developed by the Institute of Space Research of the Academy of Sciences of the USSR, for linking the "Elektronika-100I" computer with the "BENSON" graph-plotter. Programs are compiled which provide display of graphic and alphanumeric information. Instructions for their utilization are given.			
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LINKING OF THE "BENSON" GRAPH PLOTTER WITH THE "ELEKTRONIKA-100I" COMPUTER

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Introduction

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Digital units have decisively invaded the technology of modern astrophysical experiments. This has been brought about by the increased complexity of the experiments, the considerable increase in the flow of received information, the necessity of taking into account many parameters in the course of the experiment, and the necessity of controlling a complex of instruments as a function of the results of the experiments in real time. The achievements of micro-radioelectronic technology have made it possible to widely utilize small multipurpose digital computers for controlling an experiment. Created in the Institute of Space Research of the Academy of Sciences of the USSR was a complex of equipment for registration and processing of information in radio-astronomical experiments, based on the small "Elektronika-100I" computer. The "Elektronika-100I" computer is a small, rapid-action computer, the basic technical characteristics of which are given in table 1.

TABLE 1

а Система числения	б	двоичная
с Способ представления чисел	д	с фиксированной запятой
е Система команд	ф	одноадресная
г Емкость МОЗУ	h	до 32768 ячеек по 12 двоичных разрядов
д Скорость выполнения операций		
ж деления	к	3 мкс
л умножения	м	10 мкс

*Numbers in the margin indicate pagination in the foreign text.

Key: a. Number system	h. up to 32768 registers
b. binary	on 12 binary digits
c. Method of representation of numbers	i. Rate of execution of operations
d. with fixed point	j. addition
e. Command system	k. 3 microseconds
f. single-address	l. multiplication
g. Capacity of magnetic memory device	m. 10 microseconds

The registration complex, on the base of the "Elektronika-100I" computer, makes it possible to accomplish continuous registration of information with a total rate of up to 50 kHz through 64 analog signal channels. Information recording is carried out on magnetic tape in the NML-67 accumulator. Registration of a signal with a rate of up to 500 kHz of 12-digit words is accomplished through the channel of direct access to the memory. In this case, the time of continuous registration is 60 milliseconds, after which the information is re-recorded on magnetic tape within a time of about 1 second. The complex is equipped with devices for input of a digital code of up to 24 binary digits, as well as devices which cause interruption of the program on signals issued by radioastronomical equipment. In accordance with the specific program of the experiment, the computer issues control signals, which change the operating conditions of the scientific equipment. Also carried out in the course of the radioastronomical observations is processing of the data on an actual time scale. The results of the processing are indicated on an analog display. The radioastronomical information registration and processing complex was utilized for the study of the parameters of the radioastronomical equipment and for radioastronomical observations of pulsars, quasars, and other sources of cosmic radiation on the RT-22 radiotelescopes in Simeiz and Pushchino, in the decimeter range, and on the BSA radiotelescope in Pushchino at a frequency of 102.5 MHz. Processing of the obtained information is also carried out on the "Elektronika-100I" computer. With a large volume of information being processed, both the initial data and the results of the processing should desirably be represented in descriptive graphic form. Posed for this purpose was the problem

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of matching the "BENSON" graph-plotter with the "Elektronika-100I" computer.

1. Characteristics of the Graph-Plotter

The model 501 base table graph-plotter from the "BENSON-FRANCE" firm has a 50 x 75 cm working field, with electrostatic paper securing. Step-type motors ensure movement of the carriage along the orthogonal axes X and Y with a discrete of 0.1 mm, and a maximum rate of 6 cm/second. Located on the carriage is a device for securing the removable pen, and a mechanism for its raising and lowering. The drawing pens are filled with ink.

Control of the pen is possible in two modes. With manual control, displacement of the carriage is accomplished using a hinge-mounted handle. Rough adjustment at great speed is carried out in the flush position, while precise adjustment at low speed is carried out in the normal position. Movement is possible along both coordinates simultaneously.

In the automatic mode, control is carried out according to five buses: "+X", "-X", "+Y", "-Y", and "Pen Control". With delivery of a positive +5 volt pulse along the appropriate bus, the pen moves 0.1 mm. The resultant displacement ΔX , ΔY is proportional to the number of similar pulses: $X = N_1 \cdot 0.1 \text{ mm}$, $Y = N_2 \cdot 0.1 \text{ mm}$, where N_1 , N_2 are the number of pulses. Locking of the "Pen Control" bus to the frame corresponds to a lowered pen. The buses lead out to junction \mathbb{W}_1 on the side wall of the graph-plotter.

2. Device for Linking the Computer with the Graph-Plotter

A special interface was developed for controlling the graph-plotter from the computer, which makes it possible to include access to the graph-plotter in the standard system of commands of access to the external devices. The structure of the command of access to the external devices has the following form: the first three (significant) bits of the 12-digit computer word designate

the code for the command of access to the external device (6_g); the next three bits designate the number of the external device, and the last three bits permit delivery of the special control pulses (VVI). For a given number of a device, the VVI pulses may be generated along three channels (VVI1, VVI2, VVI3). The codes 50_g and 51_g were selected for the graph-plotter. The list of commands for controlling the graph-plotter is given in table 2. The scheme of the interface is given in figure 1.

TABLE 2

+ X	6502
- X	6514
+ Y	6501
- Y	6504
"UP"	6511
"DOWN"	6512

The command from the buffer register of the computer enters two diode decoders, which decode codes 50_g and 51_g . In the case of appearance of the required code, the decoder gives out an authorization potential, which enters the inputs of circuit "u". (three "u" circuits per each decoder). Control pulses VVI1, VVI2, and VVI3, respectively, enter the other inputs of the "u" circuit. Thus, pulses form at the output of the six "u" circuits which correspond to the six external device commands. The pulses are amplified and delivered to the input junction of the graph-plotter.

3. Program of Display of the Graphic Information

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For operation with the "BENSON" graph-plotter, programs of display of graphic and alphanumeric information are composed.

The program of display of the graphic information provides for establishment of the origin of the reading and the scale along the two axes X and Y of the rectangular coordinate system, and

transfer of the pen of the graph-plotter to any point in this coordinate system along a straight line with an accuracy of 0.1 mm. In addition, the program provides for plotting of the coordinate axes and their marking. The block diagram of the program is depicted in figure 2.

Control of the program is accomplished from the keyboard of the "Konsul" printer. Prior to start of the program, the pen of the graph-plotter is set in the initial position, in the required control mode. The X and Y coordinates of this position of the pen are prescribed according to the inquiry of the computer from the keyboard of the "Konsul" in the subprogram "Establishing of scale along X and Y axes".

Then, after printing of the symbol "+", automatic displacement of the pen takes place sequentially along the X and Y axes, up to receipt of the sign "+" from the "Konsul". For correction of the position of the pen, its displacement is possible at low speed in the direction of an increase or decrease in the coordinate after printing of the symbols ">" or "<", respectively. The sign "+" is the indication for stopping of the pen. Then, the symbol "x" should be printed, and, according to the inquiry from the computer, it is necessary to introduce the value of the corresponding coordinate, which is utilized by the program for establishing the scale along the given axis.

After this, according to the inquiry from the computer, the operator prints the parameters, which are required for plotting and marking of the axes (X0, Y0—the initial point from which the axis is drawn; X1, Y1—the end point to which the axis is drawn; DY, DX —the spacing along the axis used to accomplish the marking; ? —the magnitude of the dashes of the axis marking).

Operation of the program ends with receipt of the address of a specific program, and transmission of control according to this address. A program of calculation of a function, the graph of which should be depicted, or a program of selection of data from a table

and their graphic depiction, may be the specific program. Such a specific program should record the values of X and Y in the form of numbers with a floating point in registers 0165 and 0170, respectively, and access to the subprogram of displacement of the pen according to address 1540.

The block diagram of the program of displacement of the pen is depicted in figure 3. Determined first are the magnitude of ΔX and ΔY , as a function of the previous value of the coordinates. Then, the commands "+X", "-X", "+Y", "-Y" are formulated, with regard for the sign of ΔX and ΔY . The magnitudes of ΔX and ΔY are denormalized to a form with a fixed point, and pulse counters are formed for the subprogram of sending of the pulses to the graph-plotter. There are two subprograms for sending the pulses, in one of which the cycle with the command " $\pm X$ " ($\Delta X > \Delta Y$) is the inner cycle, and in the other—the cycle with the command " $\pm Y$ " ($\Delta Y > \Delta X$). The sending of the pulses is provided with a frequency of about 500 Hz, by means of organization of a program delay between the moments of delivery of the successive pulses. The program for establishing the scales, plotting the axes, and displacing the pen occupies the memory with an address from 0000 through 2600. The program utilizes a block with a floating point. The start address of the program is 0200. With multiple plottings of the graphs with an identical scale, the symbol "=" should be printed for the inquiry of the computer on the scale and the axes.

Given in figure 4 is an example of a graph obtained on the graph-plotter. Depicted in the figure are 4 sequential pulses of the pulsar PSR 0809+74, obtained as a result of processing of observations undertaken on 22 November 1977 on the large RAS FIAN cophasal antenna in Pushchino. The inscriptions on the figure are made using the program of display of the alphanumeric information.

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4. Program of Display of the Alphanumeric Information

The program of display of the alphanumeric information provides establishing of the scales along the X and Y axes, orientation of

the inscription, and plotting of the symbols. Also, just as in the preceding program, the pen of the graph-plotter is set, prior to start of the program, at the necessary point on the graph, using manual control, and subsequent control is accomplished using the "Konsul" printer. The block diagram of the program is depicted in figure 5.

After start of the program, the operator prints the symbol " \wedge ", and the computer proceeds to establish the scales and orientation. Then, the symbols are printed which designate the code of the scales along the Y and X axes and the orientation code. For example, A121 is the scale along the Y axis, first, and along the X axis, second, and the orientation, first. In figure 6, the inscription "table of symbols" is done in scale 22, orientation 1, and the inscription "utilized by graph-plotter"—in scale 44. In all, a total of 6 scales are possible along the Y axis, 6 along the X axis, and 4 orientation scales. Then, the operator prints any symbols (no more than 343 in number), and their accumulation in the memory of the computer is carried out.

After completion of input of the text, it is necessary to print the symbol " \times ", according to which the computer switches to analysis of the symbols, their identification, and plotting on the graph-plotter.

The basis of the program is breakdown of the symbols into elements and recording of these elements using a ten-digit code. The structure of the coding is depicted in the following schematic: /10

		HF			-X	4	а о ч е т ч и ж а					I
		H	+Y	-Y	+X	2	b а м п у л ь о о в					0
0	I	2	3	4	5	6	7	8	9	10	11	

Key: a. readers

b. pulses

The zero and first digits in the coding are not utilized. The unit of the second digit corresponds to the vertical and horizontal

elements, and the zero—to the sloped elements. The digits from the third through the fifth are utilized for formation of the commands of direction of the movement of the pen (+Y, -Y, +X, -X), and the sixth digit is utilized for control of the position of the pen ("UP" or "DOWN"). The last five digits are assigned to the codes of the pulse readers, which provide the size of the element.

An example of a code is: 1443—depicts an element along the Y axis in a positive direction with a lowered pen, and the code "43" corresponds to the number of pulses, which is equal to 40. Thus, for plotting of the symbols, the program makes it possible to utilize over 500 different elements. The subsequent operations of the program are displayed in the block diagram, and do not require special explanations.

Depicted in figure 6 are the 77 symbols utilized by the graph-plotter. The symbol "+" is utilized for shifting one symbol up a size in a given scale, and the symbol "←" for shifting a symbol and interval to the left a size. The keys of the "Konsul" "ommission", "line shift", overlining, and underlining are utilized according to their direct designation. The "Konsul" symbols "♦" and "|" are utilized for depicting designations of a degree and angular minutes. The angular seconds are depicted using the symbol "quotation marks". The symbols "!" and ">" are logic "no", while "!", "!", "V", and "deletion" are not plotted and are not utilized in the program for special purposes.

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The program of display of alphanumeric information occupies a memory with an address of 0000 through an address of 6700. The start address of the program is 1000, if establishment of scales and orientation is required, and 0200 is the previous scales and orientation are utilized.

The "BENSON" graph-plotter—"Elektronika-100I" computer system is being utilized successfully in the processing of radioastronomical observations of pulsars with time resolution of 10 microseconds at a frequency of 102.5 MHz.

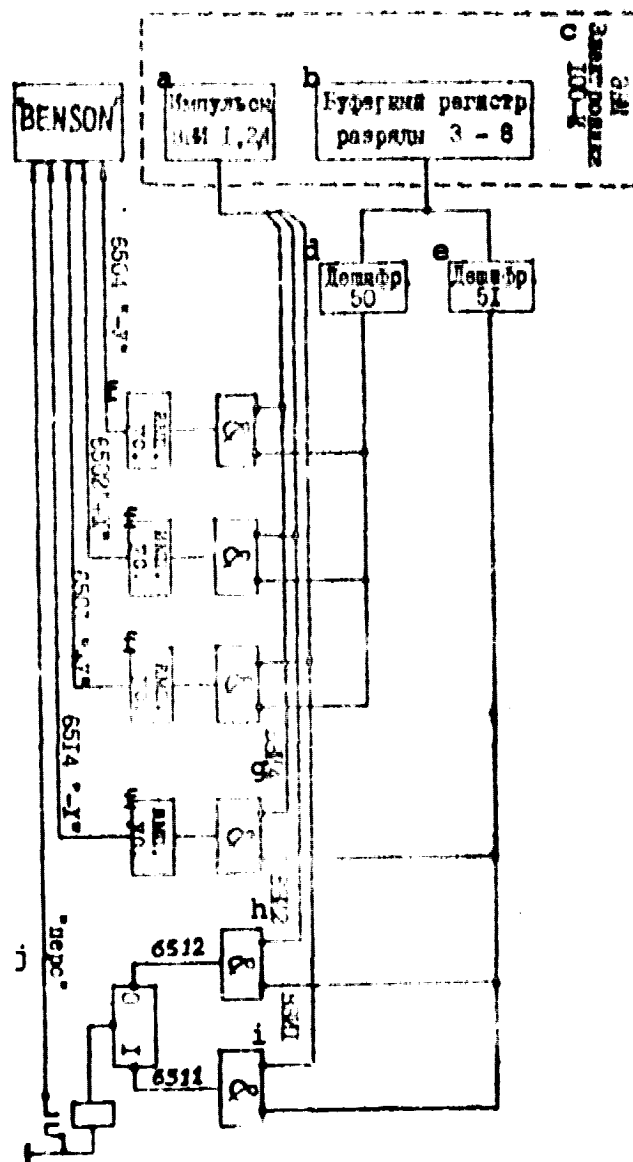


Fig. 1. Schematic of linking of "Elektronika-100I" computer with "BENSON" graph-plotter.

- | | |
|----------------------------------|--------------------|
| Key: a. VVI pulses 1, 2, 4 | f. pulse amplifier |
| b. Buffer register of digits 3-8 | g. VVI4 |
| c. Elektronika-100I computer | h. VVI2 |
| d. Decoder 50 | i. VVI1 |
| e. Decoder 51 | j. "pen" |

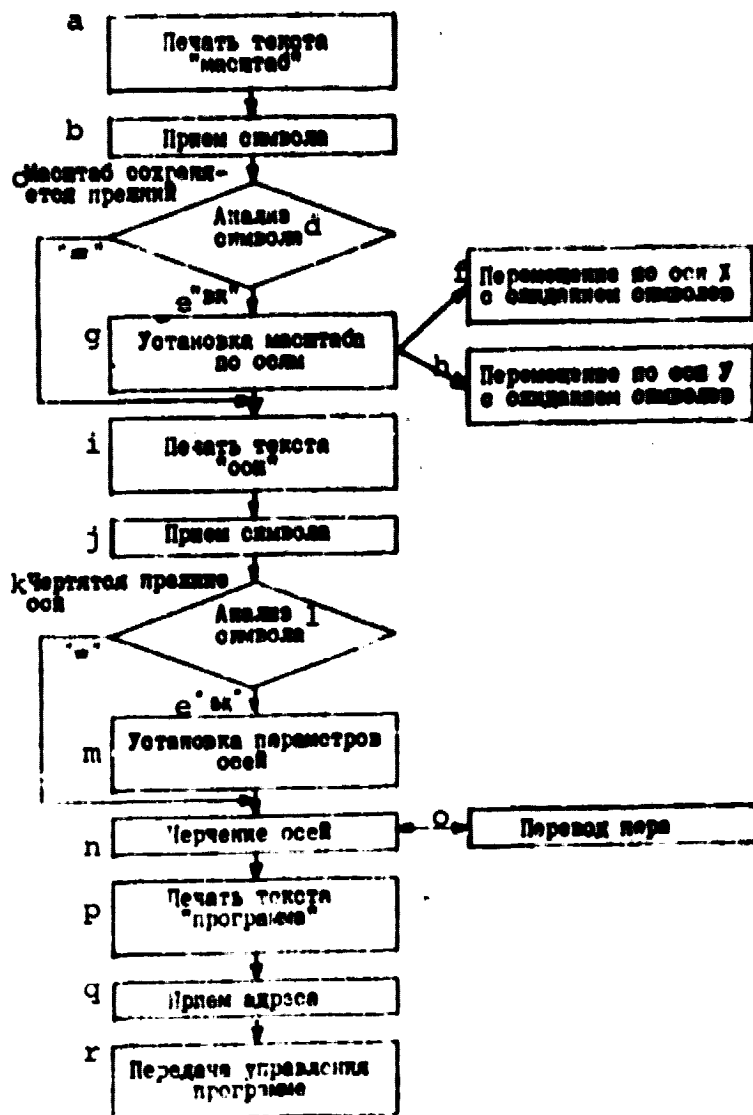


Fig. 2. Block diagram of program of display of graphic information.

- Key:
- | | |
|---|--|
| a. Printing of text of "scales" | l. Analysis of symbol |
| b. Receiving of symbol | m. Establishment of parameters of axes |
| c. Previous scale retained | n. Plotting axes |
| d. Analysis of symbol | o. Shift of axes |
| e. "vk" | p. Printing of text of "program" |
| f. Displacement along x axis with expectancy of symbols | q. Receiving of address |
| g. Establishing of scale along axes | r. Transmission of control to program |
| h. Displacement along Y axis with expectancy of symbols | |
| i. Printing of text of "axis" | |
| j. Receiving of symbol | |
| k. Previous axes plotted | |

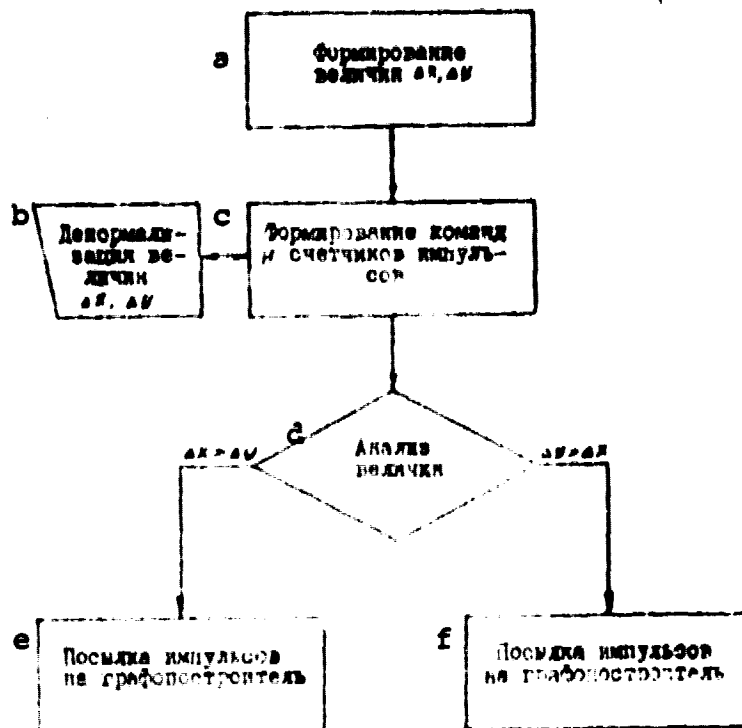


Fig. 3. Block diagram of program of control of displacement of the pen of the graph-plotter.

- Key:
- | | |
|---|--|
| a. Formulation of magnitudes of Δx , Δy | d. Analysis of magnitudes |
| b. Denormalization of magnitudes of Δx , Δy | e. Delivery of pulses to graph-plotter |
| c. Formulation of commands and counters of pulses | f. Delivery of pulses to graph-plotter |

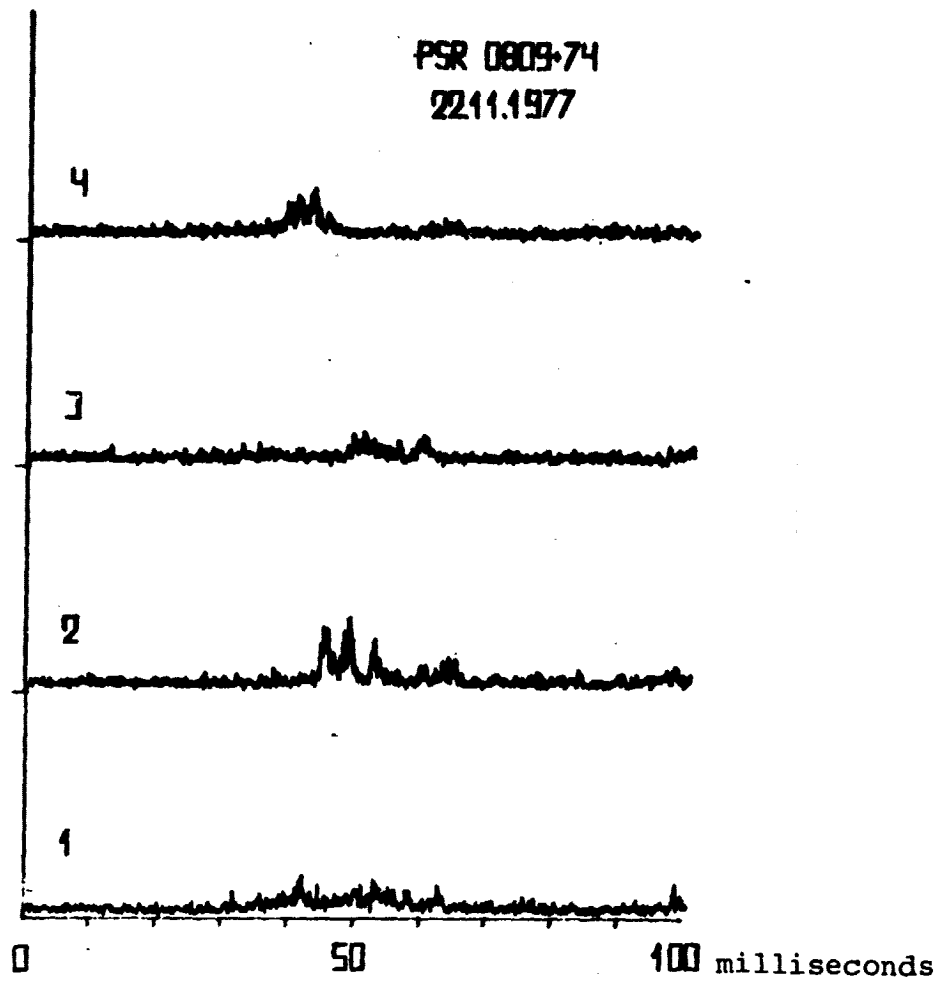


Fig. 4. Example of display of graphic information

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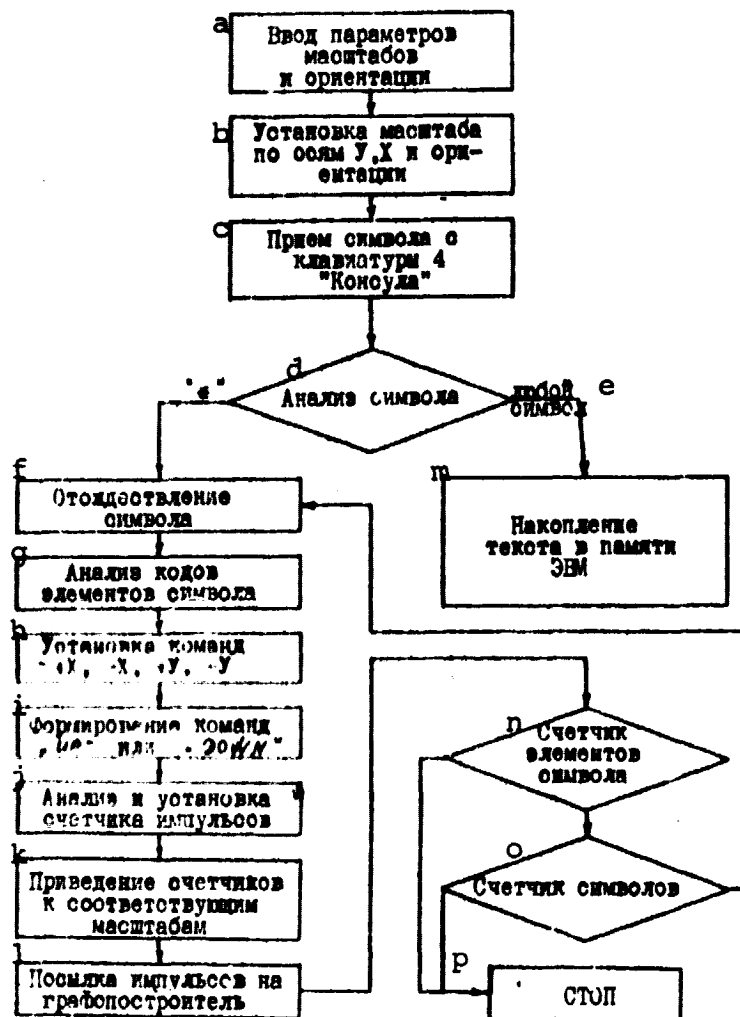


Fig. 5. Block diagram of program of display of alphanumeric information

- | | |
|--|---|
| Key: a. Input of parameters of scales and orientation | i. Formulation of commands "UP" or "DOWN" |
| b. Establishment of scale along Y and X axes and orientation | j. Analysis and establishment of pulse counters |
| c. Receiving of symbol from keyboard 4 of "Konsul" | k. Setting of counters to corresponding scales |
| d. Analysis of symbol | l. Delivery of pulses to graph-plotter |
| e. any symbol | m. Accumulation of text in computer memory |
| f. Identification of symbol | n. Counter of symbol elements |
| g. Analysis of codes of symbol elements | o. Symbol counter |
| h. Establishment of commands +X, -X, +Y, -Y | p. STOP |

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TABLE OF SYMBOLS
Utilized by the "BENSON" Graph-Plotter

1	2	3	4	5	6	7	8	9	0
А	Б	В	Г	Д	Е	Ж	З	И	Й
К	Л	М	Н	О	П	Р	С	Т	У
Ф	Х	Ц	Ч	.					
Ш	Щ	Ъ	Ы	Э	Ю	Я			
D	F	G	I	J	L	N	O	R	S
U	V	W	Z						

+	x	-	-	^	<	>	<	>	-
.	,	:	+	0	0	%			

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Fig. 6

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